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EBTRON Insight

The Importance of Controlled Ventilation in Schools

ABSTRACT

Outdoor Air Ventilation in schools promote health and wellbeing. Each individual requires a set amount of ventilation. The means to achieve ventilation is typically through mechanical HVAC systems. The minimum amount of ventilation required for schools is determined by state, provincial, and municipal codes. Many studies have determined that increased ventilation beyond the minimum may promote better health and improved performance. However, there is a cost to ventilation as it requires that the air be conditioned and filtered for the indoor environment. Therefore, efforts are made to reduce ventilation when the population in the building is reduced and when the building is unoccupied. Furthermore, the ventilation rate is impacted by the environment internal and external to the building, and by degradation and changes in operation of the HVAC systems. The result is, the amount of actual ventilation is always subjected to dynamic changes and thereby a method to measure and control the ventilation should be integrated into every system in order to provide the desired correct and efficient ventilation rate.

DISCUSSION

Children spend 12,000 or more hours in school from Kindergarten through 12th grade. It is generally accepted that the environment where they attend school has an impact in their ability to learn as well as affecting the professional staff's educational role. Enormous expenditures have been made over the past couple of decades to renovate and build new schools that create a better environment. Included is, better lighting from both light fixtures and natural light, better climate control, enhanced technology in smart board and computers, and healthier flooring, walls, and furniture. All of these things can be felt or seen and result in an improved environment. One important item not mentioned above, cannot be seen and is difficult to sense. That item is ventilation.

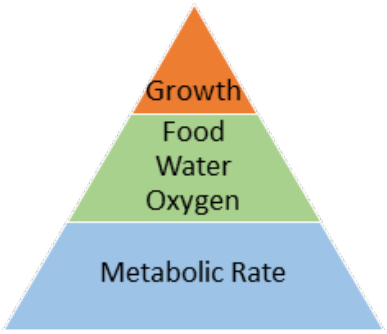
Ventilation is achieved through integration into the HVAC system and augmented in some cases by operable windows. The level of "freshness" is difficult to perceive. There may be signs or scents of significant inadequate ventilation such as mold or bad odors, but it is difficult to determine moderate ventilation from a healthy amount of ventilation. One indication of ventilation is the measurement of Carbon Dioxide (CO_2) inside the space. The reason why CO_2 is used as an indicator of ventilation is that each human generates a quantity of CO_2 depending on their age, sex, body mass, diet, and activity level. It is important to note however, that the value of CO_2 in the space is not a positive measurement of the correct amount of ventilation. Furthermore, it does nothing to identify if the building, classrooms, and school are positively pressurized.

The lack of pressurization results in air from outdoors being sucked, otherwise known as infiltrated, into the building through doors, windows, walls, and roof. This brings in unconditioned and unfiltered air into the building. Unfiltered air can lead to degradation to the building and items within it, as well as the potential for allergic reactions by the occupants. Depending on the season, the air may be colder, hotter, or of higher humidity levels than the internal environment. This situation can lead to wasted energy, an uncomfortable space, damage to the envelope, or mold growth which results in further costly damage and may result in a health hazard. The only accurate way to determine if ventilation rates are sufficient and that the building is properly pressurized is to directly and actively measure and control the outdoor airflow rate. When the measured outdoor air is used by HVAC systems to control the rate of air in and out of the building, it will not only establish the correct ventilation rates, it will also ensure the correct pressure relationship from indoors to outdoors preventing unintended infiltration.

Infiltration is a result of an imbalance of airflows going into a building or space when compared to the airflows leaving the building or space. When the balance in a building or space is negative, it will result in sucking air from an adjacent space or through the envelope. Airflow will always find a path to move, and can cause disruption in its movement, such as hard to open or close doors. There are various operational situations that can cause this imbalance. In regions where high humidity is common, the result of high water content of the air, there is a strong potential for moisture condensing as the air is brought into a space that is cooler. Typically, this happens when the outdoor dew point is above 60°F. The condensation of the moisture in the air may be visible or not seen as it may happen on the walls, behind wall paper, within the walls, on or above the ceiling, on furniture, floors, and more. The result of this repeated action may result in mold or other harmful bacteria to grow. A study of 2751 Schools in upstate NY showed a correlation between mold, moisture and ventilation problems with absenteeism.[1] The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE)[2], states that mold growth results in significant costs for repair and disruption of operation. They state that building dampness and mold have been documented to be associated with adverse health outcomes related to asthma and upper respiratory problems. They indicate that the risk of mold increases when failing to keep the long-term average indoor air pressure positive with respect to the outdoors when the outdoor dew point is higher than indoor surface temperatures; and failing to measure and limit the volume of ventilation and makeup air as was intended by the design and the potential of the equipment.

Deferred maintenance and repairs can also be a contributor to the problem. Often when mold is found in a building, it causes disruption to the operation of the school. The school is then faced with the need to displace the students and staff, hiring professionals to investigate the properties of the mold, evaluate the damage caused, try and determine the cause, and perform a remediation of the affected areas. Many times, the cause is not determined because there are no installed airflow sensors that can provide information that is needed to determine the pressure relationship. Remediation is then done without a root cause, and the problem then happens in the future. Several schools have had repeated problems with mold, even if they spent significant funds to upgrade the HVAC systems, because they failed to add air flow measurement and control in the new systems[3] . In some cases, the HVAC system is found at fault and it is corrected[4,5], however, this is well after the damage is done when it could have been detected before with continuous measurement of airflow. Also note, that balancing the system one time is not a means to keep the system operating with the correct pressure balance.

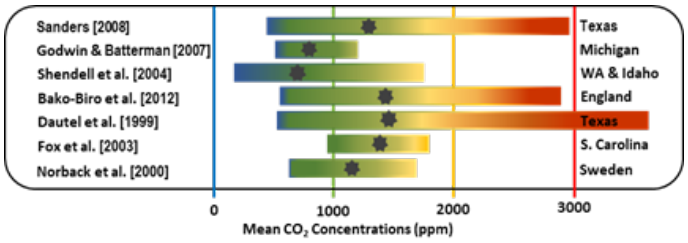
Temperature changes from season to season, wind variations, and mechanical degradation can change the pressure balance of a building. Continual measurement and control of the airflow will compensate and indicate when these imbalances happen.



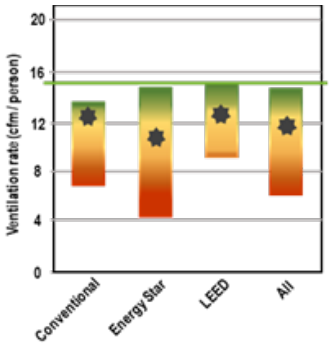
According to the Principles of Pediatric Environmental Health[6], children breathe more air, drink more water, and eat more food per kilogram of body weight than do adults (figure [1]). This result in greater exposures per kilogram of body weight to any contaminants in the air, water, or food, as compared with adults. Harvard University's School for Health, links a student's health to their thinking, resulting in increased academic performance[7] . It references an estimate by the EPA that more than 60,000 schools or approximately 46% of U.S. public schools have environmental conditions that contribute to poor Indoor Environmental Quality (IEQ). An EPA report on the environment estimated that indoor pollutants can be 2 to 5 times higher than outdoor concentrations[8] . Dilution and room air changes with outdoor air ventilation, is a proven means to reduce indoor pollutants. The University of Exeter stated that poor ventilation results in a 5% decrement in "Power of Attention"[9].

There are several studies that link poor ventilation in school to school attendance. A study in California of 28 schools (162 5th grade classrooms) in 2010, found over 50% of them were below the code ventilation rate. It correlated a reduction of illness of 1.5% for every 2 cubic feet per minute (cfm) of outdoor air increase[10]. Allowing for ventilation is not enough, it should be measured, monitored, and controlled. There are many things that can affect the outdoor airflow intake from providing the correct amount of outdoor air. They include, but are not limited to, normal changes of direction and speed of wind and associated wind gusts, temperature changes from summer to winter, dirty filters, damper and actuator failures, and improper control sequences. By constant airflow measurement and control integration, the amount of outdoor air can be adjusted to suit dynamic Figure [1] The Importance of Controlled Ventilation in Schools October 2019 changes and alarm when problems that are detected. Furthermore, integrating measurement and

control of the exhaust air within the building, combined with the outdoor air measurement and control, can prevent or notify of a situation that would result in infiltration.



An ASHRAE research project showed classrooms being poorly ventilated with the CO_2 levels routinely reaching 1500-2000 ppm[11]. A review of multiple studies showed CO_2 reaching higher concentrations[12] (figure [2]). High CO_2 or VOC levels are difficult to detect by occupants and are indicators of in adequate ventilation[13]. A study of 28 schools and 166 classrooms of 3rd, 4th, and 5th grades found the mean ventilation rate was 8.5 cfm per student where it should have been 15 cfm14. There is an abundance of evidence that our schools are under ventilated. A means to start to identify and correct this, would require active measurement and control of the outdoor airflow.



Most recently, there was a study performed across 4 Midwest states that included 37 recently constructed or modified schools. The schools consisted of 10 that were of standard construction, [15] that met Energy Star® construction requirements, and 12 that were LEEDTM certified. Every school was delivering less outdoor air ventilation than the design and the minimum requirements of the building code (figure [3]). The mean ventilation rates, were all less than the required minimum15. Although LEED requires alarming when the ventilation rate is outside of +/- 15% of design, there was no indication in the study that any alarms were triggered. Even if they were, it takes action of the maintenance staff to try to rectify the problem. This indicates that this crisis, is across all building types, new and old, even those built to as high performance with the best green or energy intent. Outdoor airflow measurement is not a one-time balance, set and forget. The ventilation airflow measurement should be an active control input into the HVAC system, then it will ensure that outdoor air intakes are adjusted to provide the correct ventilation air, also allowing the measured value to be viewed on a regular basis. This could identify situations when something in the system causes the rates not to be achieved. Some recent investigation looked into the effect of too much CO_2 in a space, as a result of inadequate ventilation. One of its findings was at 1,000 ppm CO_2 , compared with 600 ppm, an individual's performance was significantly diminished on six of nine metrics of decision-making. They stated "the direct impacts of CO_2 on performance indicated by our findings may be economically important, may disadvantage some individuals, and may limit the extent to which outdoor air supply per person can be reduced in buildings to save energy"[16]. A separate study found cognitive function scores were 15% lower for a moderate CO_2 day (~ 945 ppm) and 50% lower on the day with CO_2 concentrations of (~1,400 ppm)[17].

CONCLUSION

Outdoor air ventilation is necessary for the health and well-being of occupants. Maintaining the chosen ventilation rate is a dynamic problem that requires real time measurement and control. The ventilation and related exhaust within the school has a direct impact to building pressurization that is essential in maintaining IEQ and long-term integrity of the building, and all of its contents. It is important that schools start taking control of the indoor environmental quality. If you don't measure it, you can't control it. Measurement, control, and fault alerts should be the foundation of any mechanical system upgrade, or the basis of a new school HVAC system. The first cost of incorporation of airflow control in an HVAC system is minimal as compared to the future impact and cost as a result of over ventilation, inadequate ventilation, and infiltration. As the leader in airflow measurement and control, EBTRON has the broadest range and most accurate solutions available to the market. Accuracy and application have an important impact to successful airflow management.

ADDITIONAL RESOURCES

There is acknowledgment that Indoor Air Quality is a big concern in schools, and the importance of having the correct ventilation. The following resources and tools have been created to address this important topic:

- Energy Savings Plus Health: Indoor Air Quality Guidelines for Schools – EPA
- Schools for Heath: Foundations for Student Success- Harvard University T.H. Chan School for Public Health
- Impact of School Buildings on Student Health and Performance- The Center for Green Schools
- Indoor Air Quality Scientific Findings Resource Bank – Lawence Berkley National Laboratory
- Ebtron.com

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2. ASHRAE Position Document – Limiting Mold and Dampness in Buildings
3. Howard County Council- HCPSS Mold Report
4. Chicago Tribune- Parts of East High School closed after mold outbreak
5. WDRB- Rebuilt school in Henryville, Ind. fighting mold problem
6. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry – Principles of Pediatric Environmental Health
7. Harvard University T.H. Chan School for Public Health- Schools for Heath: Foundations for Student Success
8. Environmental Protection Agency Report on Indoor Air Quality- What are the trends in indoor air quality and their effects on human health?
9. University of Exeter – The Effect of Low Ventilation on the Rates of Cognitive Function of a Primary School Class
10. Lawrence Berkley National Lab- Association of Classroom Ventilation with Reduced Illness Absence: A Prospective Study in California Elementary Schools
11. ASHRAE RP-1257- Indoor Environmental Effects On The Performance Of School Work By Children
12. Journal of Environmental Economics and Management- Indoor air quality and academic performance
13. Indoor Air- Association between substandard classroom ventilation rates and students' academic achievement
14. Lawrence Berkley National Lab – Demand Control Ventilation and Classroom Ventilation
15. Indoor Air- Ventilation Rates in Recently Constructed U.S. School Classrooms
16. Environmental Health Perspectives- Is CO2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO2 Concentrations on Human Decision-Making Performance
17. Environmental Health Perspectives- Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments